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September 28, 2006

The Honorable Nicole Nason
Administrator
National Highway Traffic Safety Administration
400 7th Street, S.W.
Washington, DC 20590

RE: Comments on Tire Aging, Docket 2005-21276

Dear Administrator Nason:

We are submitting a statistical analysis of the agency's "Phoenix Tire Dataset" (Version 4.0) along with the following comments for consideration on the tire aging issue.

Quality Control Systems, Corp. (QCS) performed the attached statistical analysis at our request to determine whether an age effect on tire performance in an endurance test could be established from the agency's "Phoenix Tire Dataset." While the limitations in the available data prevented us from making any sweeping conclusions about an age effect on tires, the QCS analysis does provide valuable insight that the agency should consider as it proceeds toward rulemaking.

The QCS report found that data from four of the six tire models collected and tested by NHTSA did not contain enough diversity in the population to allow for a meaningful analysis. Therefore it could not determine whether an age effect independent of tire mileage exists. However, there was sufficient diversity in tires C and E (Goodyear Eagle GA and Firestone Wilderness AT respectively) to reach some conclusions.

With respect to the Firestone tires both age and mileage were very predictive of time to failure in the stepped-up load tests. However, the age of the tire was a notably better predictor of time to failure in the Firestones than mileage, even in this small sample. The data on the Goodyear tire show that knowing age and mileage are not as predictive and that mileage is a better predictor when all data are included. This apparent lack of age effect of the Goodyear Eagle GA is discussed further in the analysis.

Despite limited nature of the analysis, these findings invite some commentary. Of the two tires models in which there was enough diversity to allow for analyses, one is high-speed rated (Goodyear - "V" rated) the other is not (Firestone - "S" rated). High-speed rated tires are generally designed with a more robust construction to handle the increased demands that accompany high speeds. This robust construction is likely to have an impact on the performance of a tire as it ages. Features like high-halobutyl content inner liners and cap plies, among others, are known to have a positive effect on belt-edge separations and enhance the likelihood a tire will remain intact for a longer time.

Some will argue that comparing the Firestone and Goodyear is an "apples-to-oranges" comparison. However, both tires were provided as original equipment for their respective applications yet the margins of safety over time appear to differ greatly. This apparent difference in robustness over time is important—and it is important for consumers to know. Consumers are not likely to equate a speed rating to tire safety over time, but if this significant difference exists between models, brands, speed ratings, etc., the onus is on the industry to provide meaningful recommendations about the limits of their products.

Assuming that there is a significant difference between tire models with respect to how they age, general guidelines should be considered by the agency as an interim measure. Our prior submissions to the docket provided information about vehicle manufacturer guidelines that have been in existence since 1990 in response to studies in Germany that showed a disproportionate increase in tire failures after six years.[1] [2] [3] Subsequently, the number of vehicle manufacturer recommendations have grown and the six year recommendation has been reaffirmed by Ford Motor Company's recent research.

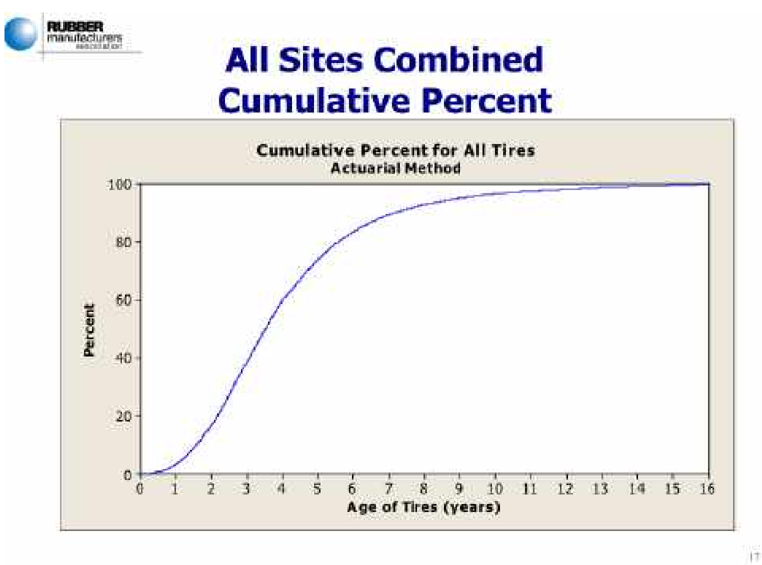
The recent RMA study submitted to the tire aging docket claimed that the purpose of their study was to "collect data relevant to tire service life."[4] This study doesn't directly examine tire service life. Rather, it is based on visual inspections of tires only after they have been trucked into large regional scrap tire processing centers. The RMA's primary observation was that, based on the date codes, there was no spike in the data that indicated tires were being removed from service at a particular time. As a result the RMA concluded there is no "magic date" when a tire is taken out of service and "chronological age" does not determine service life of a tire. The survey results show that most tires are removed from service because of wear, followed by road damage. One obvious flaw with the RMA survey is that they are examining the wrong tires as most

[1] Docket 15400-12, September 17, 2003
[2] Docket 15400-31 and 15400-32, November 5, 2004
[3] Docket 21276-5; May 25, 2004 and Docket 21276-9, August 4, 2005
[4] Docket 21276-15, RMA May 10, 2006

were removed from service due to wear and road damage, not from catastrophic failures like tread / belt separation. A more meaningful survey would include tire property damage and injury claims. However, these data are not available for public review, nor are they captured in the Early Warning Reporting (EWR) data.[5] As noted in our comments to the docket, EWR do no require manufacturers to report claims involving tires older than five years, a flaw that we urge the agency to correct.

The tires in the RMA survey were taken out of service at some point prior to their arrival at these centers. However, the RMA did not determine how long these tires had been out of service. The RMA concluded that "wear-out" rates are independent of age after the first year and that road damage rates are independent of age. This means that year after as these tires age year after year, they don't wear-out or suffer any additional road damage as they age. If that were true, what kinds of tires are they? One possible explanation that may answer this question is that many tires had been taken out of service long before they were received at the processing center where the RMA inspected them. If so, the tires wouldn't be wearing-out or suffering road damage no matter how much older they got. Without knowing when the tire was taken out of service, these data are less relevant to tire service life.

A key observation noted in the RMA study is that the scrapped tires in their study followed a "smooth curve" and there was "no 'magic date' when a tire is taken out of service . . . Therefore [one] cannot say that chronological age alone determines the service life of a tire."

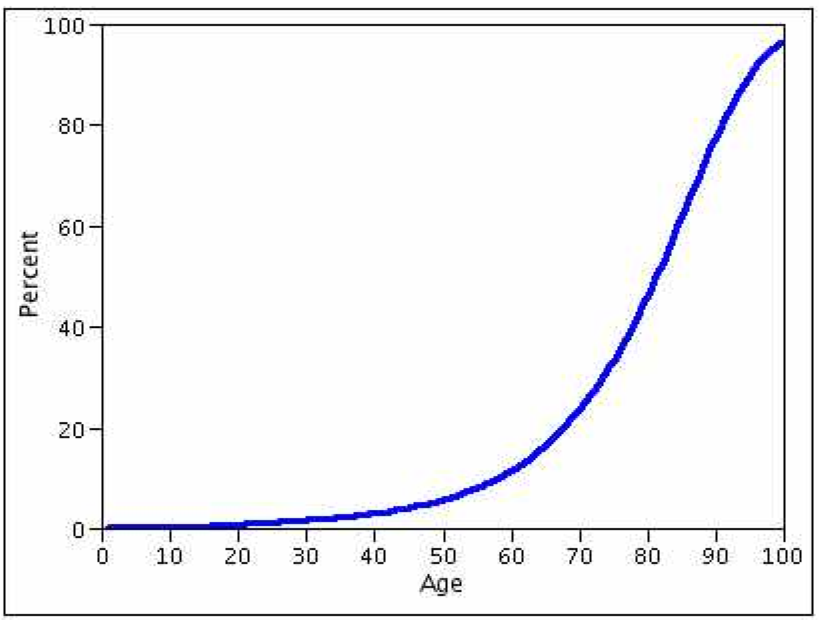


(Table from p. 17 of RMA report)

[5] Docket 21276-20, July 27, 2006

It appears that the RMA are trying to approach these data as though they measured actuarial risk. However, RMA data are only about scrapped tires—no information is provided that reflects the size of the underlying populations that have generated these scrapped tires. The RMA has simply provided the proportion of tires that are scrapped, which *may* have only an indirect bearing on risk. If this is a risk table, then the 6-year-old tires present an 80 percent risk, 2-year-old tires present about an 18 percent risk.

The graphic below reflects the "service life" of a human population—cumulative deaths by age for a cohort of newborns through each age of life to 100 years.[6] This too can be characterized as a "smooth curve" with no "spike." Following the RMA's logic, one could not say that chronological age alone determines the lifetime of a human being. However, it is well recognized that chronological age is a very good guide.



The difference between this chart showing cumulative mortality risk for people and the RMA's chart for tires is that the chart for human beings is based on mortality rates that take into account how many people die as well as the size of the population

[6] The graphic above is derived from data available taken from Table 1. Life table for the total population: United States, 2003, "United States Life Tables, 2003," National Vital Statistics Reports, Volume 54, Number 14, April 19, 2006, National Center for Health Statistics, Centers for Disease Prevention and Control, Atlanta, GA.

alive at each specific age during a given period of time. RMA has tires that are "dead" but have no measurement for the size of the population from which the scrapped tires they were drawn from.

Like the RMA "smooth curve," the life table for human beings shows no sudden "spike" or "magic age" that determines a human life span. Does this mean because there is no jarring threshold we should not set a limit on human capacity to do jobs like piloting commercial aircraft? Setting guidelines based on increasing levels of risk is done in a variety of areas from ranging from life insurance premiums to blood alcohol (BAC) limits for motorists.

Finally, in a November 5, 2004 petition for rulemaking SRS requested that the agency require a consumer-friendly date of manufacture molded into tire sidewalls. We requested this action to help consumers determine the age of their tires at a glance. Our petition requested that this rulemaking be addressed separately from the tire performance standards so as not to become mired in that lengthy process. We also noted that a simple date of manufacture would not create a conflict with other possible requirements regardless of any future agency action on the issue of tire aging. We are disappointed to learn that the agency has decided to lump this petition into the tire performance rulemaking. The result is that consumers and service technicians are denied an easy to discern date of manufacture—information that NHTSA, and the tire and vehicle manufacturers all agree is vitally important. We urge reconsideration and ask that the agency address labeling separate from the performance issues.

In summary:

- Analysis of the Phoenix Tire Dataset provides insight into the different aging characteristics of tires and should be considered by the agency as it progresses toward rulemaking recommendations.

- The RMA study reaches inappropriate conclusions about tire age. More meaningful analyses can be done. Unfortunately, the most useful data on tire-related claims for property damage, injury and death are out of public reach because they are being kept secret by NHTSA. Further, claims for older tires are unavailable to NHTSA in the EWR data despite the fact that claims involving older tires are known to be important to motorist' safety.

- Tire age is a risk factor that needs to be considered by motorists. It is well understood within the industry that tires have differing characteristics and result in differing levels of degradation over time. Despite these differences, it is reasonable for the agency to consider communicating that risk vis-à-vis a consumer advisory. SRS requested that the agency consider this interim approach and subsequently, Ford Motor Company has also asked NHTSA to consider this as well. Again, we urge consideration of a consumer advisory.

- Because tires have differing characteristics that will result in differing levels of degradation over time, the tire industry should advise motorists of the expected useable life of their products, irrespective of tread wear.

- NHTSA should modify EWR requirements such that manufacturers must report all tire claims, regardless of the age of the tire.

- We request NHTSA to begin rulemaking, separate from tire performance, that would require the date of manufacture to be molded onto the tire sidewalls as an important interim step toward addressing tire aging issues. This date, in contrast to the current tire identification coding, should be in a format that is readily seen and easily understood by consumers.

Sincerely,

Sean E. Kane

Stepped-Up Load Testing

NHTSA's Phoenix Tire Dataset (Version 4.0) • Tire Aging Study • Statistical Analysis

Report by Quality Control Systems Corporation • www.quality-control.us

Report for
Safety Research & Strategies, Inc.

September 19, 2006

Stepped-Up Load Testing

NHTSA's Phoenix Tire Dataset (Version 4.0) • Tire Aging Study • Statistical Analysis

Report by Quality Control Systems Corporation • www.quality-control.us

Two Wilderness AT

Tires

Pre- and Post-Test

The National Highway Traffic Safety Administration (NHTSA) has been testing tires through its Vehicle Research and Testing Center (VRTC) in an effort to quantify the amount of degradation that occurs with tire age and usage. Part of this testing has involved running a "Stepped-Up Load (SUL) to Failure Test," based on NHTSA's FMVSS 139 Endurance Test. This test is performed under conditions of increasing load over time according to the specifications shown below.[1]

Test Stage (#)	Duration (hours)	Percent Max Load	Speed (mph)	Test
1	4	85%	75	*FMVSS 139 Endurance*
2	6	90%	75	
3	24	100%	75	
Inspection	**1**	**-**	**-**	**-**
4	4	110%	75	*Stepped-Up Load to Catastrophic Failure*
5	4	120%	75	
Etc.	4	+10% every 4 hours	75	

The Sample

The results for six tire types in the Stepped-Up Load tests have been published to date, including 92 total SUL tests in Version 4.0 of the dataset.[2] The general characteristics of these tires varied by type as shown below.[3]

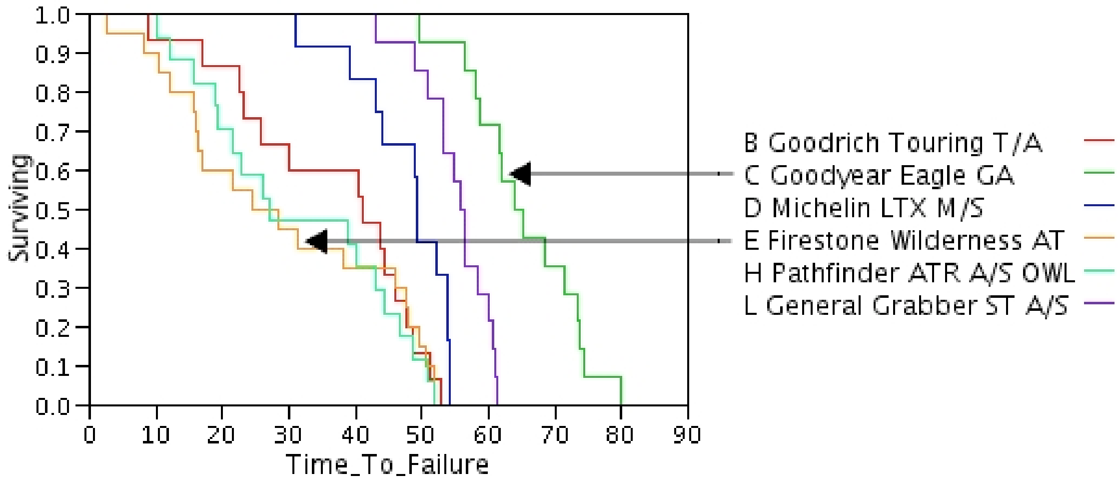
Tire Type	Tire Size	Load Index	Speed Rating
B Goodrich Touring T/A	P195/65R15	89	S
C Goodyear Eagle GA	P205/65R15	92	V
D Michelin LTX M/S	P235/75R15	108	S
E Firestone Wilderness AT	P265/75R16	114	S
H Pathfinder ATR A/S OWL	LT245/75R16/E	120/116	Q
L General Grabber ST A/S	255/65R16	109	H

The number of tires of each type tested are shown below, along with the average survival time and standard error for each. Note that this analysis includes new tires as well as two spare tires: one Wilderness AT spare and one Eagle GA spare. (JMP statistical software was used for data management and analysis.[4])

Tire Type	Sample Size	Average Time-to-Failure (hrs.)	Standard Error
B Goodrich Touring T/A	15	36	4
C Goodyear Eagle GA	14	65	2
D Michelin LTX M/S	12	48	2
E Firestone Wilderness AT	20	29	4
H Pathfinder ATR A/S OWL	17	32	4
L General Grabber ST A/S	14	55	1
All Types Combined	92	43	2

Stepped-Up Load Time-to-Failure

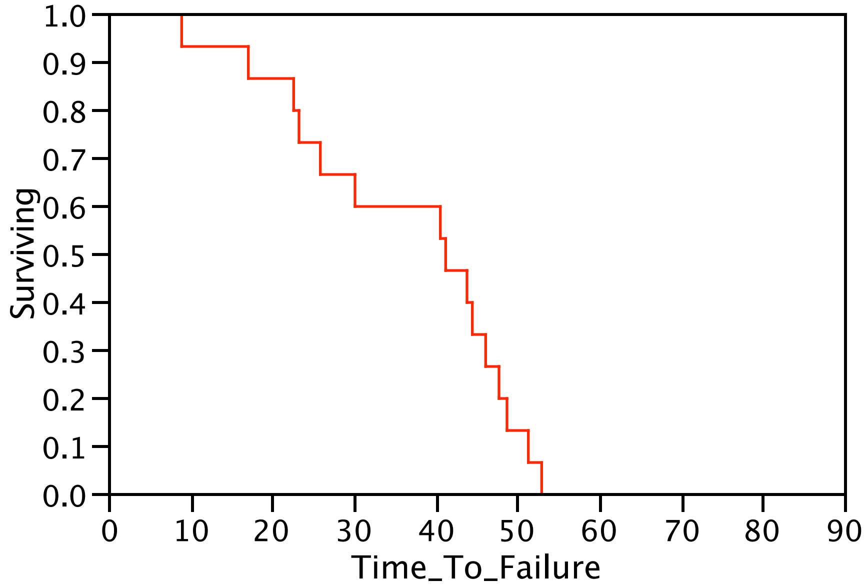
A "survival plot" of the six tire types is shown in the figure below. The y-axis of the plot corresponds to the proportion of the original sample of tires that has not failed (that "survives") at a given point in time in the test. The x-axis shows the time-to-failure in hours for each tire.



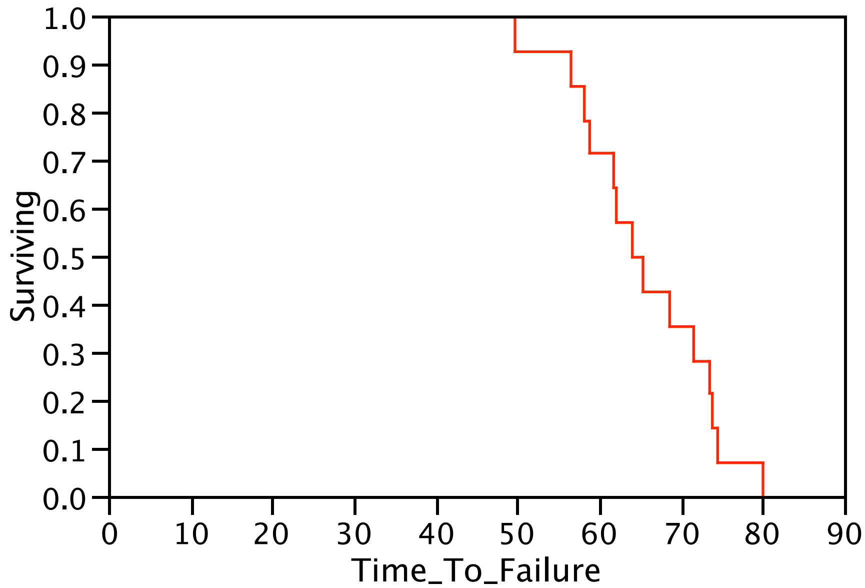
Each tire type is represented in the survival plot by a line of a specific color shown in the accompanying key. The colored line drawn for each tire type could be described as a set of descending stairs. Looking left to right with the passage of time in the test, each vertical "riser" represents a tire that failed at a particular point in time corresponding to the horizontal x-axis of the plot. The length of the stair tread corresponds to the length of time until the next failure of a tire of that particular type.

There were no censored observations for any of the six tire types as all of the tires were tested to failure. There were no failures of the Goodyear or General tires before the 34 hour limit of the FMVSS 139 Endurance Test and only one failure for the Michelin tire.

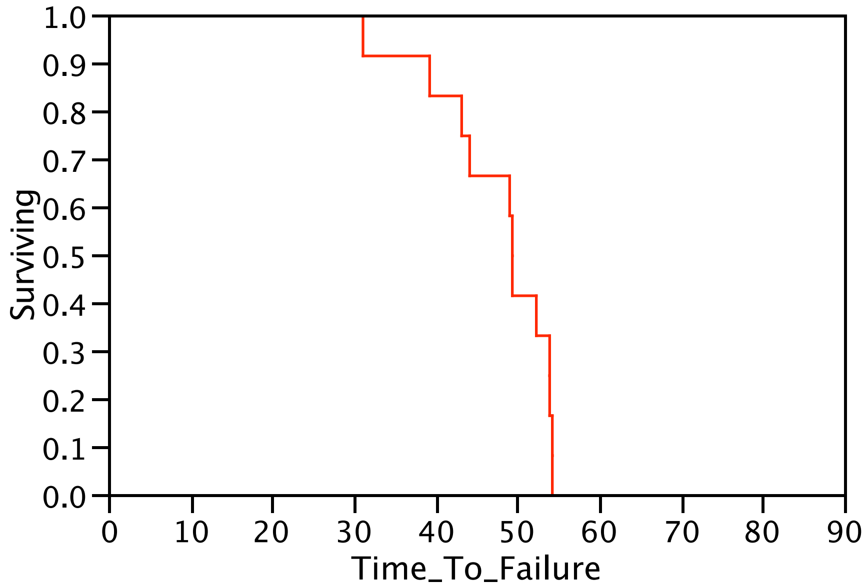
Survival plots are shown below for each of the six tires separately.



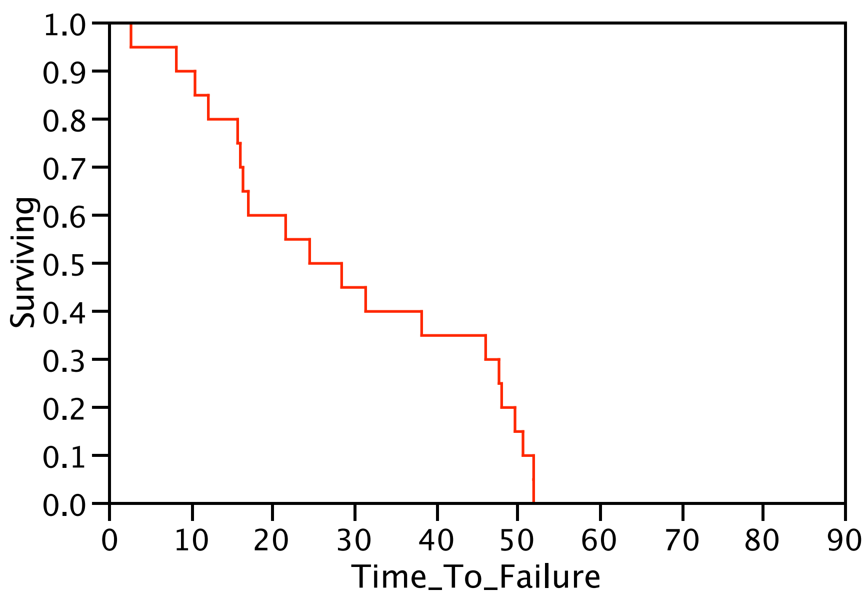
Type B - Goodrich Touring T/A



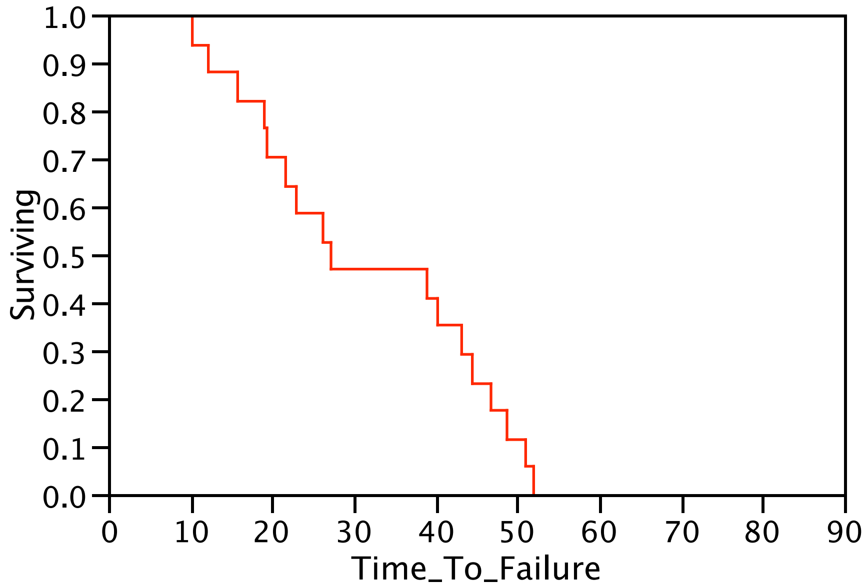
Type C - Goodyear Eagle GA



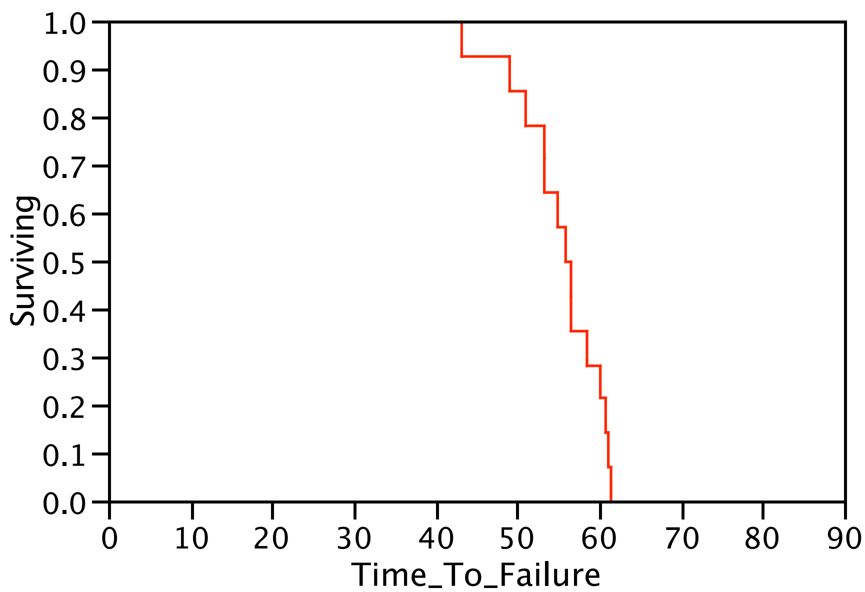
Type D - Michelin LTX M/S



Type E - Firestone Wilderness AT

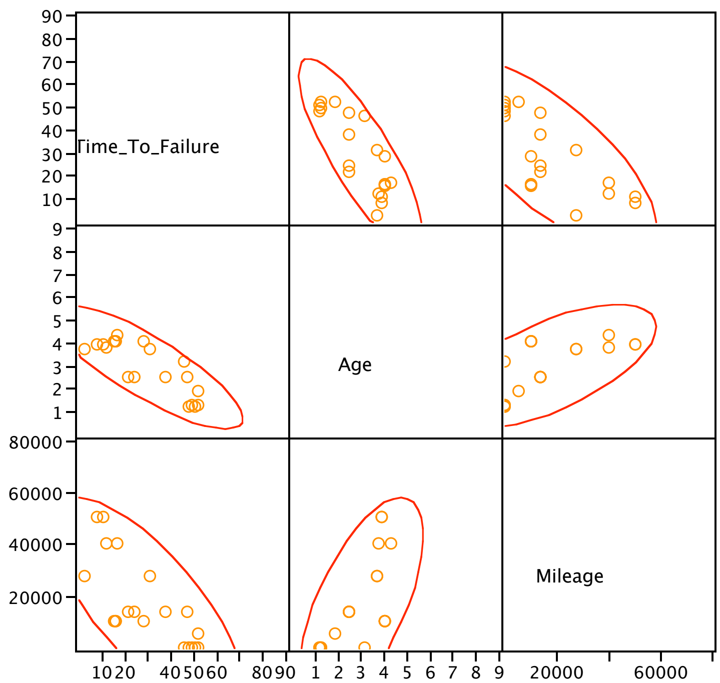


Type H - Pathfinder ATR A/S OWL



Type L - General Grabber ST A/S

There were 20 SUL tests of the Firestone Wilderness AT tire (Tire type E). The bivariate distributions of the estimated tire age in years, estimated tire mileage, and time-to-failure in this test are shown in the figure below, along with an ellipse that would enclose 95% of the points under an assumption of bivariate normality. The more circular and horizontal an ellipse, the less the variables are correlated with each other. Note that a few of the plotted points are clustered very close together.



"Mileage" represents the actual vehicle odometer mileage for OEM tires, but it is an estimate for replacement tires. Estimated mileage for replacement tires was calculated by multiplying the tire age (determined by its DOT number and the tire collection date) by the average annual vehicle mileage (determined by dividing the odometer mileage by the vehicle age based on the DOT number and the tire collection date). New tires have zero mileage. The variable "Age" used in the figure above and in the analyses that follow is an estimate of the age of the tire in years at the time of testing. This estimated age was determined based on the DOT number and the "Invoice_ Date" for the test. This estimate is not the same as as the variable, "DOT_Age," that is given in the original dataset. The definition of age used here is based on our understanding that the "Invoice_ Date" in the dataset is reasonably close to the actual date of testing for the two road wheel tests, stepped-up load and stepped-up speed.

The Pearson product-moment correlations between estimated age, estimated mileage, and time-to-failure are shown below for the Wilderness AT tires tested.

	Time-to-failure	Age	Mileage
Time-to-failure	-	-0.83	-0.74
Age	-0.83	-	0.64
Mileage	-0.74	0.64	-

These results suggest that the correlation between age and mileage (0.64) requires some attention in the model estimation which follows.

We estimated a Cox proportional hazards model for the 20 Wilderness AT tires adjusting for tire age and mileage, first separately and then jointly. As seen in the first set of results shown below, estimated tire age is a statistically significant predictor of time-to-failure in the SUL tests of the Wilderness AT tire.

Whole Model

Number of Events	20
Number of Censorings	0
Total Number	20

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	9.94470	19.8894	1	<.0001
Full	32.39092			
Reduced	42.33562			

Parameter Estimates

Term	Estimate	Std Error	Lower CL	Upper CL
Age	1.47591568	0.4176588	0.7501514	2.4167517

Risk Ratios

Term	Risk Ratio	Lower CL	Upper CL
Age	4.37504	2.117321	11.20939

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Age	1	1	19.8893917	0.0000

Substituting estimated tire mileage for estimated age resulted in a model that predicted time-to-failure less well, based on a comparison of the likelihood ratio Chi-square statistic that is lower for this model than for the model that includes only age.

Whole Model

Number of Events	20
Number of Censorings	0
Total Number	20

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	7.63381	15.2676	1	<.0001
Full	34.70181			
Reduced	42.33562			

Parameter Estimates

Term	Estimate	Std Error	Lower CL	Upper CL
Mileage	0.00007798	0.0000207	0.0000388	0.0001215

Risk Ratios

Term	Risk Ratio	Lower CL	Upper CL
Mileage	1.000078	1.000039	1.000122

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Mileage	1	1	15.2676218	0.0001

Finally, we estimated a model for the combined effects of tire age and tire mileage for the Wilderness AT tire. Comparing the likelihood ratio Chi-square statistic calculated for this model in comparison with either of the two models shown above demonstrates that age and mileage taken together work somewhat better to predict time-to-failure than either variable taken on its own for the Wilderness AT. Note, however, that the p-value for mileage is not statistically significant at the traditional level in this model of the joint effects.

Whole Model

Number of Events	20
Number of Censorings	0
Total Number	20

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	11.35730	22.7146	2	<.0001
Full	30.97832			
Reduced	42.33562			

Parameter Estimates

Term	Estimate	Std Error	Lower CL	Upper CL
Age	1.19738849	0.4623279	0.3347096	2.1948942
Mileage	0.00003672	0.0000225	-0.000006	0.0000843

Risk Ratios

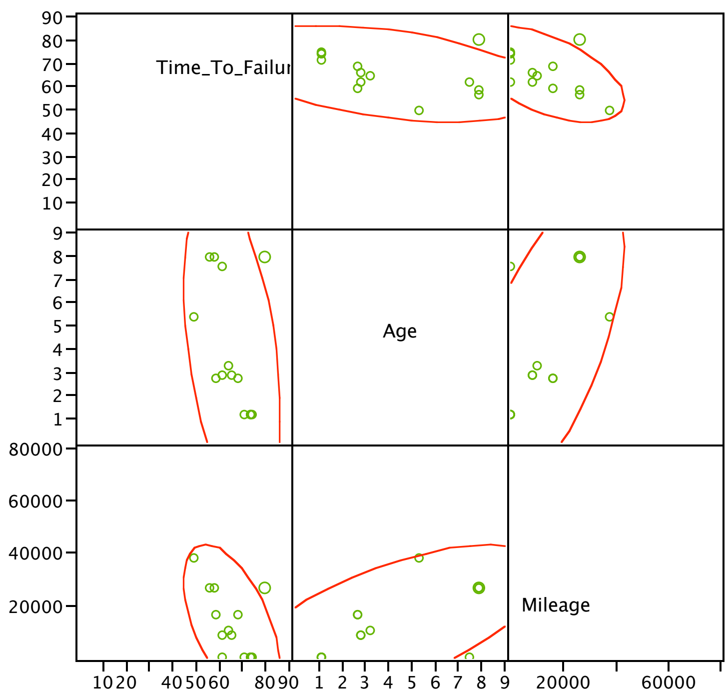
Term	Risk Ratio	Lower CL	Upper CL
Age	3.311458	1.397534	8.979051
Mileage	1.000037	0.999994	1.000084

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Age	1	1	7.44697082	0.0064
Mileage	1	1	2.82520098	0.0928

Similar results were also obtained when the single spare tire was removed from the Wilderness AT sample.

The independent relationship between estimated tire age, estimated tire mileage, and time-to-failure in the SUL testing may not be conclusively demonstrated for all tire types in the sample. For example, here are the results for the Goodyear Eagle GA tire. The bivariate distributions of estimated tire age, estimated tire mileage, and time-to-failure in this test are shown in the figure below for this tire, along with the 95% density ellipse in each box of the graphic. A few of the plotted points are clustered quite close together. Note particularly the outlier in the plots for time-to-failure by age and time-to-failure by mileage. This tire, barcode 0306, lasted the longest of the 14 Goodyear tires tested, even though it is the "oldest" tire and has the highest estimated mileage.



	Time-to-failure	Age	Mileage
Time-to-failure	-	-0.39	-0.55
Age	-0.39	-	0.65
Mileage	-0.55	0.65	-

Were tire 0306 to be removed from this pool of 14, the correlations of age and mileage with time to failure would be decidedly different.

	Time-to-failure	Age	Mileage
Time-to-failure	-	-0.75	-0.86
Age	-0.75	-	0.61
Mileage	-0.86	0.61	-

Whether or not this data point is kept, however, doesn't materially affect the correlation between tire age and mileage.

The results of the estimated Cox proportional hazards model with age and mileage are shown below for the SUL testing of the Goodyear Eagle GA tire with all 14 points. Neither the estimated coefficient for tire age nor the tire mileage coefficient is statistically significant. In fact, the model itself does not pass the traditional test for statistical significance. The estimated risk ratio for tire age is less than one - meaning that time-to-failure is likely not a function of tire age for the Eagle GA tires in this test. Nevertheless, it should be kept in mind that there are only 14 observations available to estimate a two factor model for this tire type.

Whole Model

Number of Events	14
Number of Censorings	0
Total Number	14

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	0.62680	1.2536	2	0.5343
Full	24.56442			
Reduced	25.19122			

Parameter Estimates

Term	Estimate	Std Error	Lower CL	Upper CL
Age	-0.10589	0.2264739	-0.584995	0.2745453
Mileage	0.0000491	0.0000563	-0.000048	0.0001643

Risk Ratios

Term	Risk Ratio	Lower CL	Upper CL
Age	0.899524	0.557109	1.315932
Mileage	1.000049	0.999952	1.000164

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Age	1	1	0.23351586	0.6289
Mileage	1	1	0.84346339	0.3584

Removing the spare tire from the sample for this tire had a detectable effect on these results, making the calculated likelihood ratio Chi-square statistic for the model itself more nearly statistically significant ($p < 0.09$). This is most likely due to the fact that the spare tire (with zero mileage) was fairly old at the time of testing, (more than 7.5 years) and that there were only 13 tests remaining to estimate the model.

A more important change comes from removing the point for tire 0306. Keeping the spare, but removing point 0306, yields the estimated model shown below.

Whole Model

Number of Events	13
Number of Censorings	0
Total Number	13

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	10.26484	20.5297	2	<.0001
Full	12.28733			
Reduced	22.55216			

Parameter Estimates

Term	Estimate	Std Error	Lower CL	Upper CL
Age	0.6916863	0.310477	0.1440766	1.4795275
Mileage	0.00016348	0.0000763	0.0000444	0.0003713

Risk Ratios

Term	Risk Ratio	Lower CL	Upper CL
Age	1.99708	1.154973	4.39087
Mileage	1.000163	1.000044	1.000371

Effect Likelihood Ratio Tests

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Age	1	1	6.19016007	0.0128
Mileage	1	1	8.41626694	0.0037

Not only is the model itself now statistically significant, but both coefficients are statistically significant as well. Note that the parameter estimate for estimated age has the theoretically expected (positive) sign without point 0306.

Unfortunately for simplicity's sake, removing the spare tire (0318) from the pool of 13 (after removing tire 0306) leaves estimated tire age and mileage too highly correlated (0.85) to reasonably estimate a model including the joint effects of age and mileage.

Discussion

The results reported here are based on a small number of tests. An additional limitation of these models is that the tested tires are not "independent." That is, within each specific tire type, a number of vehicles contributed more than one tire that is included in these tests. Further, the ratio of tires tested to sampled vehicles is not the same for each tire type. The positions from which the tires were taken from vehicles (right front, left front, right rear, left rear, and spare) are also not balanced by tire type. It is unfortunate that the age and usage of the tires tested are too highly correlated within many of the tire types to reliably model their independent effects.

Comparisons between tires should be made with the recognition that the different tire types were tested at differing loads at any given time in the testing, based on each tire's specific load index. Comparisons of performance between tire types should take into account differing initial conditions of tire age and tire mileage as well. These differing initial conditions are not indicated in the simple survival plots shown on pages 4 through 6.

The apparent lack of a tire age effect for the Goodyear Eagle GA tire with all 14 points included invites an explanation. From a theoretical standpoint, the possibilities include at least the following: 1) that estimated tire age and estimated mileage are more often misreported or miscalculated for the Eagle GA tires in the sample than for the Firestone Wilderness AT tires; 2) the SUL test, as designed and carried out, is not a valid test of tire aging and degradation either for the Wilderness AT or for the Eagle GA tire or both; or 3) that the Eagle GA is robust in comparison to the Wilderness AT, such that time-to-failure in the SUL tests is more a function of its design and manufacturing characteristics than a function of the tire's age or its mileage. From a practical standpoint, it could be reasonably argued that the results from the SUL tests for this tire type are too sensitive to the inclusion of specific data points to support any of these conclusions.

Acknowledgment

We gratefully acknowledge the assistance of Mr. James D. MacIsaac at NHTSA's Vehicle Research and Test Center in answering many questions about this dataset promptly, thoroughly, and in detail.

References

1. "Interim Update –NHTSA Tire Aging Test Development Project," NHTSA, James D. MacIsaac Jr., May 12, 2004.

2. NHTSA URL: http://www-nrd.nhtsa.dot.gov/vrtc/ca/NHTSAPhoenixTireDataset/NHTSAPhoenixTireDatasetV4-0.xls,. accessed September 6, 2006.

3. "NHTSA Phoenix Tire Dataset Version 4.0," NHTSA, URL: http://www-nrd.nhtsa.dot.gov/vrtc/ca/NHTSAPhoenixTireDataset/NHTSAPhoenixTireDatasetV4-0Notes.pdf, accessed September 6, 2006.

4. *JMP*, Version 5.1.1, Cary, NC: SAS Institute Inc.; 2004.